

Status of sPHENIX

TPC

Simulations

for

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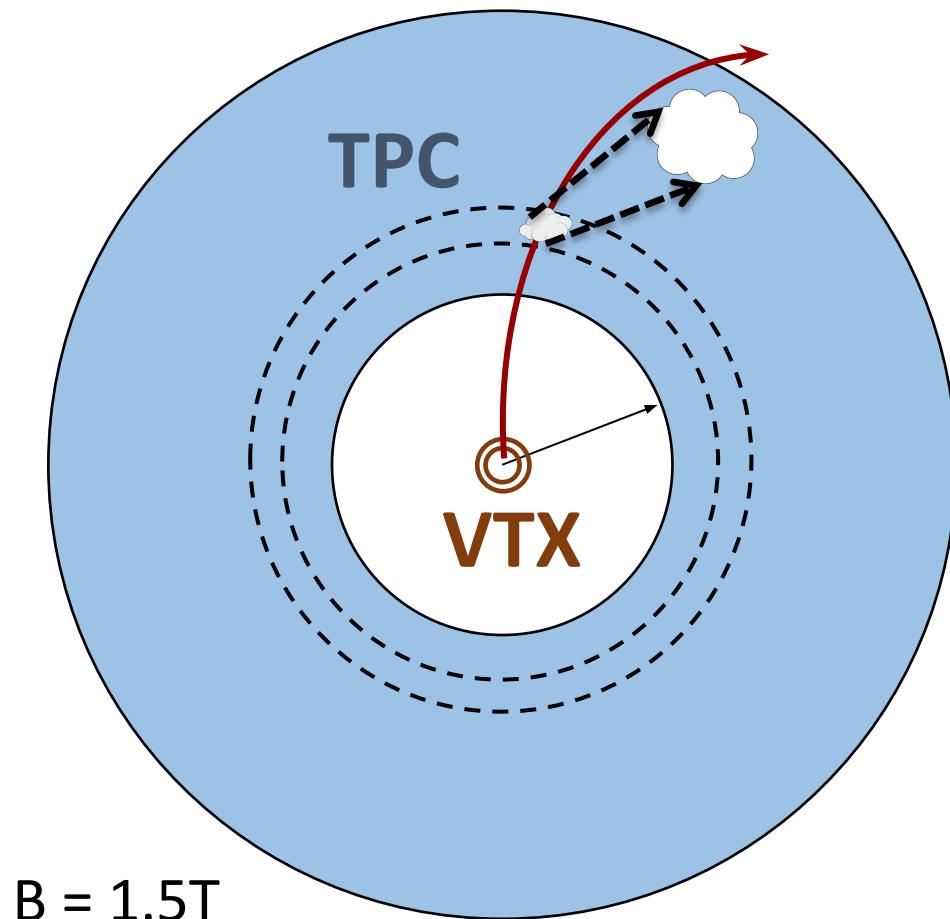
TPC simulation goals

- Evaluate cost/benefit to add TPC to sPHENIX
- Primary figure-of-merit = Upsilon mass resl'n
- Additional physics considerations
 - jet fragmentation
 - jet-medium interations
 - fluctuations (wishful BES topic)
 - day-1 EIC detector (wishful, but not crazy)

Implementation Strategy

- Full scale (slow) simulator requires significant effort, too long for this stage
- Analytic methods (Gluckstern) highlight potential performance gains, but not costs
- Fast simulator goal : translate TPC gas, fields, and readout pitch into resolution

Fast TPC simulator pictograph



- Determine ΔE thru radial segment from Geant
- Convert to ionization electrons
- Parameterize charge cloud diffusion with z_{drift}
- Distribute electrons across 2D pads
- Reconstruct hits with cluster finder
- Fit track through hits
- Calculate dE/dx (not implemented yet)

Fast TPC simulator equations

- General formula for Gaussian diffusion width
 - $\sigma_z^2 = D_t^2 z_{\text{drift}} / N_t + \sigma_{z0}^2$
 - $\sigma_{r\phi}^2 = D_t^2 z_{\text{drift}} / N_t / (1 + \omega^2 \tau^2) + \sigma_0^2$
- Parameters
 - N_t = ionization electrons (PDG tables)
 - $\omega\tau = v_{\text{drift}} B / E$
 - v_{drift}, D_t obtained from measurement or Magboltz
- For T2K gas (95-3-2), 220 V/cm, 1.45 Tesla
 - use measurements made for ILC study (next slide)
 - use σ_0 measured for triple-GEM readout

ILC study comparison

Comparison with calculated values,

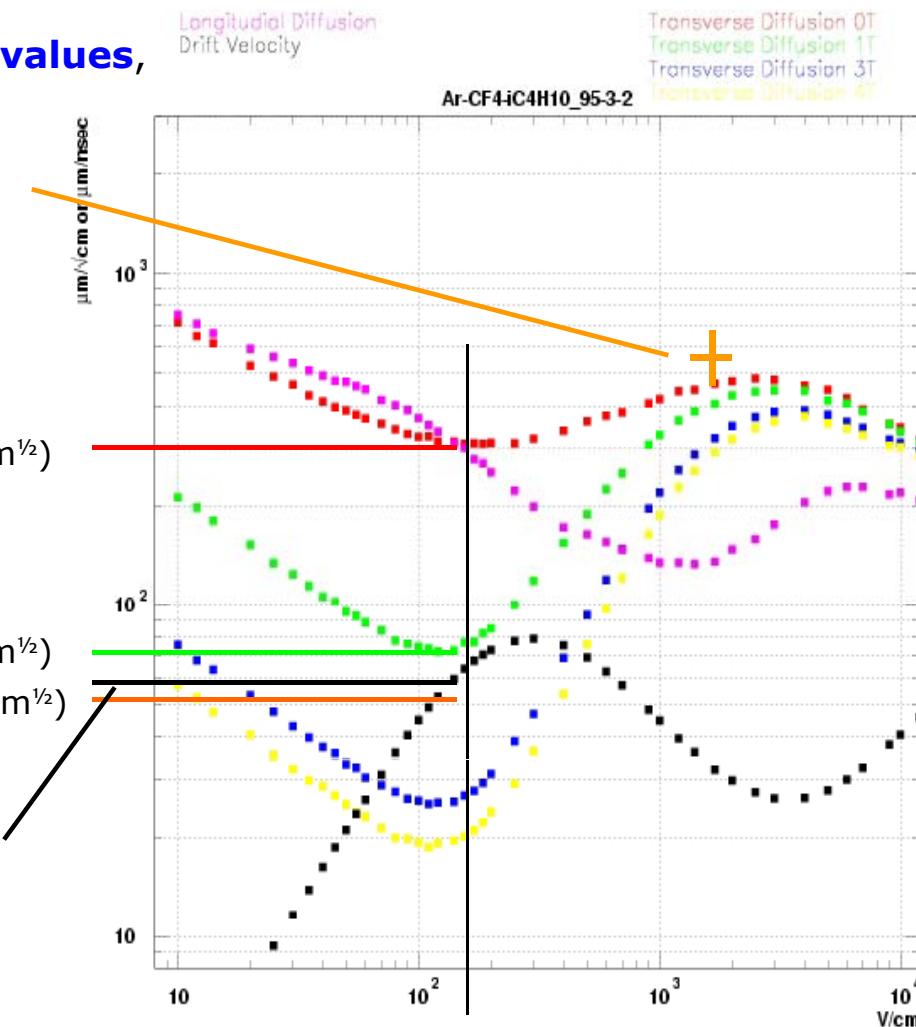
<http://www-hep.phys.saga-u.ac.jp:80/ILC-TPC/gas/>

D(GEM), B=1.45 or 1.0 Tesla
measured $0.55 \text{ mm}/(\text{cm}^{1/2})$
about $1.4 \times$ calculated

D_t , B=0, measured $0.298 \text{ mm}/(\text{cm}^{1/2})$

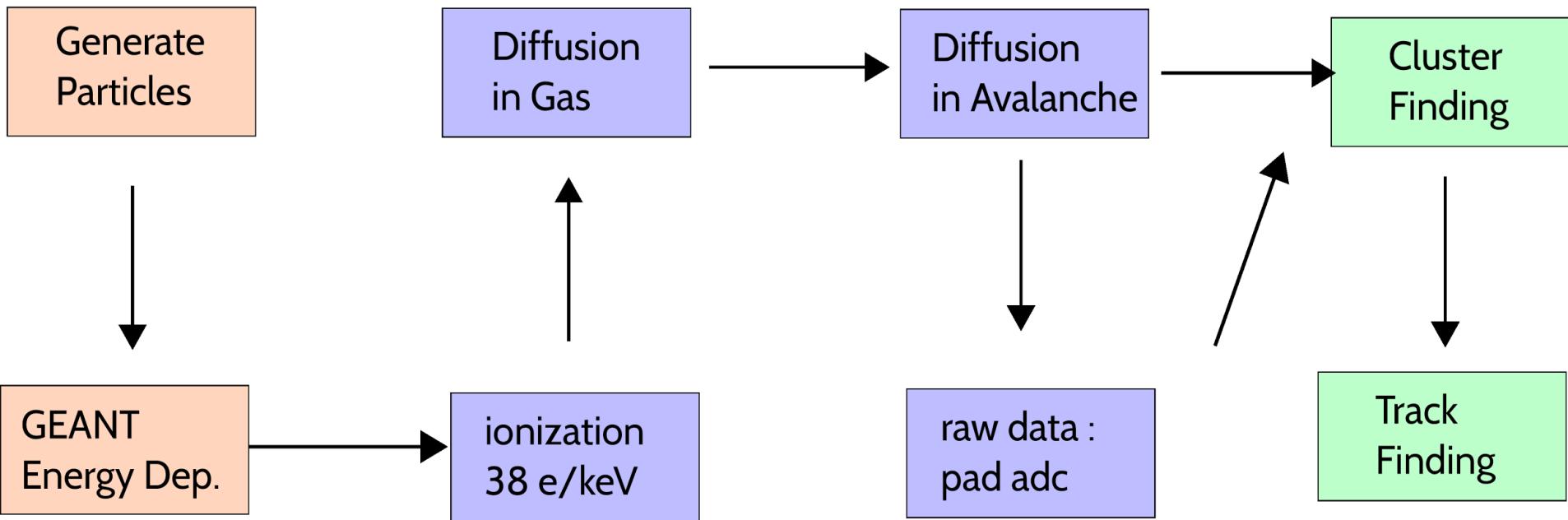
D_t , B=1.0T, measured $0.071 \text{ mm}/(\text{cm}^{1/2})$
 D_t , B=1.45T, measured $0.052 \text{ mm}/(\text{cm}^{1/2})$

Drift velocity: (370-87) bins
40ns/bin, 65cm drift length
 $V_d = 57 \text{ mm}/\mu\text{s}$



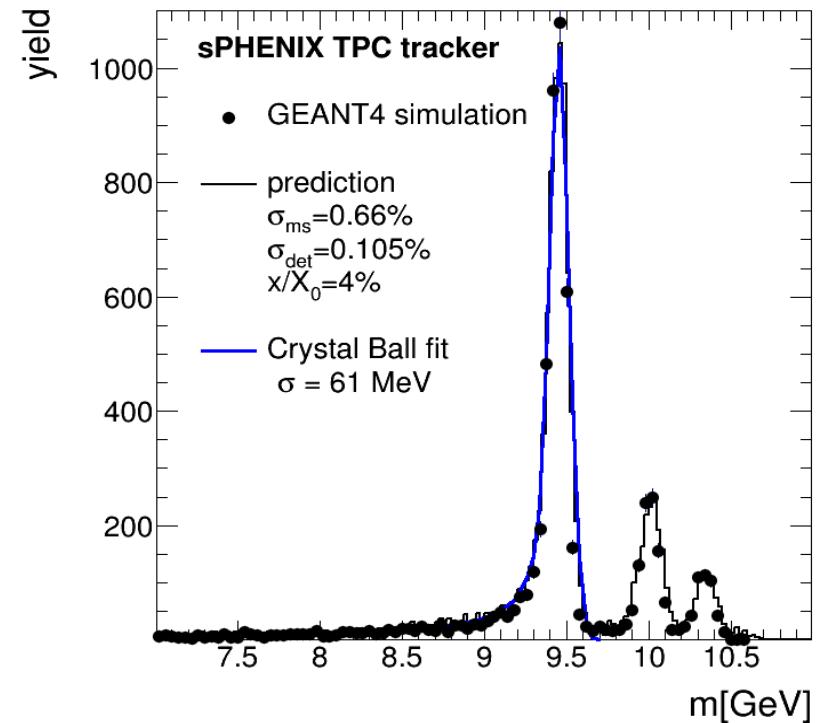
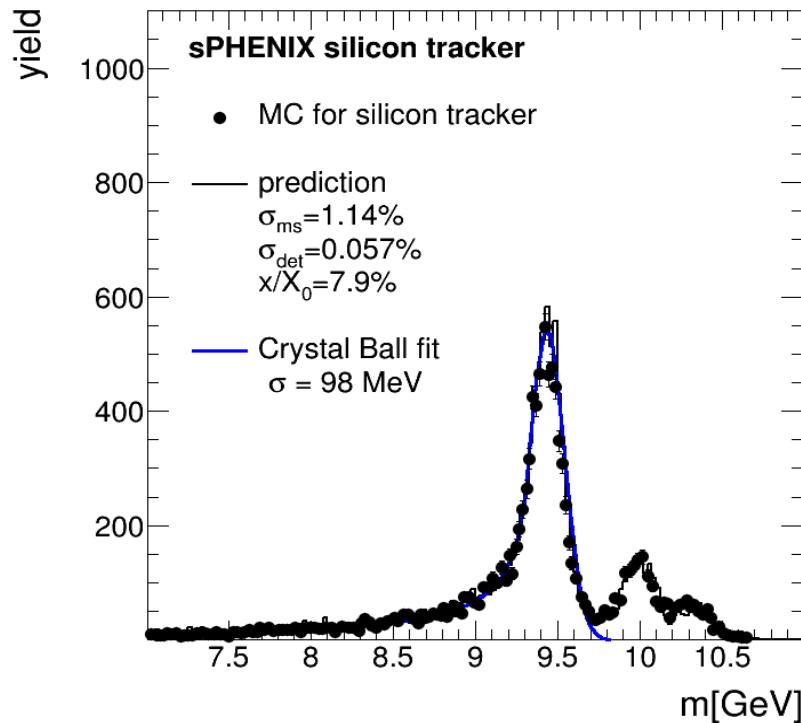
Alan's TPC Fast Simulator Schematic

Flow Chart of GEANT Simulation & Analysis



Comparison Plot for Current Status

GEANT4 Simulation of Upsilon Measurement



- Si Left, TPC Right, Analytic formula in blue
- Conclusion: TPC Fast Simulator is Working !

Next Steps

- Improve distribution of ionization electrons
(along primary ionization points)
- Improve charge sharing on pads
- Plot and verify dE/dx distributions
- Test in low multiplicity environment (pythia)
- Increase multiplicity (hijing)

Evaluate performance (and cost)

- Vary azimuthal readout pitch
- Vary radial readout pitch
- Vary Gas and E-field
- Test single vs. dual direction drift
- Cost evaluation will require modest workup

Missing from Fast Simulator

- No ability to study ion-backflow and charge distortions
- No ability to study amplification, GEMS and microMegas
- Require more in-depth simulation tools, measurements, and more effort
- Goal for next month : Determine feasibility